A Macro Disequilibrium Model for Switzerland

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1 Introduction

Considerable work has been done in recent years on estimating macroeconomic disequilibrium models. Important examples are Sneessens (1983), Kooiman and Kloek (1985), Sneessens and Drèze (1986), Lambert (1988) and Laroque (1988). The basic notion in these models is that prices and wages adjust too slowly to clear markets permanently so that agents on the 'long' side of a market may get *rationed* and revise their trade plans, causing thus quantity *spillovers* across markets. At first glance, in view of official unemployment rates that hardly ever exceeded 1%, the attempt to construct such a model for Switzerland may appear as a somewhat far-fetched exercise. Contrasting with low unemployment, however, output and employment have in fact been more volatile in Switzerland than in the majority of other countries. At the same time, prices and wages moved rather sluggishly. Not surprisingly then, many econometric studies have had difficulty in describing developments over longer periods of time with stable parameters. Against this background, the potential of a disequilibrium model that allows for endogenous transitions between different regimes is quite obvious.

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The present study extends the usual set-up of empirical disequilibrium models in two directions. *First*, the development of the production structure is described on basis of a *putty-clay* type *vintage model* which determines investment, scrapping, notional output supply and labour demand in terms of relative factor costs, profitability and excess demand. *Second*, the model allows for a production smoothing *buffer role* of inventories. Toning down Blinder (1980, 1981), who argues that the existence of buffer stocks would largely prevent spillovers and rob disequilibrium models much of their interest, a buffer specification is proposed that modifies the link between current demand and output but stays *within* the basic disequilibrium framework.

The paper is organized as follows. Section 2 describes the spillover effects at the firm level and introduces buffer stocks. Section 3 converts this micro model into smooth macro relationships, showing how unobserved demands and supplies on the markets for goods and labour are mapped onto observed aggregate transactions and regime proportions (measured by survey data). Section 4 specifies the aggregate econometric equations. Section 5 outlines the method of estimation. The parameter estimates are discussed in section 6. Section 7 analyses the development of the Swiss economy on basis of model simulations. Section 8 summarizes and draws some conclusions.

2 The micro model: rationing and spillovers at the firm level

Generally speaking, micro goods and labour markets are linked through (a) firms' decisions on goods supply and labour demand, (b) households' decisions on goods demand and labour supply. We focus here on link (a), taking thus into account that firms rationed in labour demand curtail effective output supply and that firms facing a 'sales constraint' react by reducing effective labour demand. Spillovers in the household sector will be either neglected —since a reduction in labour supply arising from rationed goods demand seems unlikely— or accounted for in a traditional Keynesian manner — by making consumption demand dependent on realized income.

Following Kooiman (1984), firms are viewed as hypothetical micro production units, supplying goods and demanding labour on specific micro markets. Based on the short-run production function, the individual firm is assumed to decide on the optimal levels of employment and output; these are the firm's *notional* trade offers, henceforth denoted by $\tilde{l}^d$ and $\tilde{y}^s$. The firm is confronted then on the labour market with a supply l^s and on the goods market with a demand y^d.

Defining the ratios:

$$z = \frac{l^s}{\widetilde{l}^d} \qquad \text{and} \qquad x = \frac{y^d}{\widetilde{y}^s}, \tag{1}$$

we specify the firm's *effective* trade offers as:

$$l^d = \widetilde{l}^d \min(x^\gamma, 1) \tag{2}$$

$$y^s = \widetilde{y}^s \min(z^\delta, 1) \qquad \gamma, \delta > 0 \text{ spillover elasticities.} \tag{3}$$

Transacted employment and output are given by

$$l = \min(l^s, l^d) = \widetilde{l}^d \min(z, x^\gamma, 1) \tag{4.1}$$

$$y = \min(y^d, y^s) = \widetilde{y}^s \min(z^\delta, x, 1). \tag{4.2}$$

We assume that a firm constrained by labour supply ($z < 1$) moves along a concave production function, thus suffering a less than proportionate spillover onto output. This implies $0 < \delta < 1$. If the firm in case of a 'sales constraint' ($x < 1$) were to stay on the same efficient production frontier, the effective labour demand function would just correspond to the inverse of effective output supply, *i.e.* $\gamma = 1/\delta > 1$. Labour productivity would then however increase in recessions, which is counter-factual; to generate the empirical productivity cycle, we assume $0 < \gamma < 1$ [(1)].

Depending on the values of x and z, each firm finds itself in one of *four possible regimes* (boundary cases can be assigned arbitrarily):

- If $x > 1$ and $z > 1$ (Classical unemployment) the firm realizes its notional trade offers: $y = \widetilde{y}^s$ and $l = \widetilde{l}^d$.
- If $x < 1$ and $x^\gamma < z$ (Keynesian unemployment) the firm is constrained by y^d and we have: $y = y^d$ and $l = \widetilde{l}^d x^\gamma$.
- If $z < 1$ and $z^\delta < x$ (Repressed inflation) the firm is constrained by l^s and we have: $y = \widetilde{y}^s z^\delta$ and $l = l^s$.
- If $z < x^\gamma$ and $x < z^\delta$ (Underconsumption) the firm is constrained on both markets, *i.e.* $y = y^d$ and $l = l^s$.

In the model presented so far, goods demand y^d acts as strict upper bound on output. This appears somewhat unrealistic in a model

(1) This also ensures that the coherency conditions are met; see Quandt (1988).

that is to be applied to quarterly data since firms are likely to *smooth production* in relation to fluctuating demand, using inventories or unfilled orders as *buffer stocks*. Such behaviour can be substantiated with convex cost functions and/or specific costs of changing the output level (a). In addition, firms typically have to decide on output before they know current demand (b). Both factors imply that firms determine output on basis of some concept of 'expected demand' which —due to motive (a)— refers to the longer term. We shall now modify the above analysis along these lines[2].

Assuming that firms use *either inventories of finished goods* (iv) or *unfilled orders* (uo) as buffer stocks, the following firm-level definitions arise (beginning-of-period stocks):

$$iv = iv_{-1} + y_{-1} - y^d_{-1} \qquad uo = uo_{-1} + y^d_{-1} - y_{-1}. \tag{5}$$

Demand y^d corresponds to sales and order inflow respectively. Firms are assumed to equate 'long-term expected demand' to 'profitable capacities',

$$E(y^d) = \tilde{y}^s, \tag{6}$$

by setting prices —thereby influencing $E(y^d)$— and by adjusting $\tilde{y}^s$ through investment and scrapping. In the short run, y^d will fluctuate around $E(y^d)$. The possibility to carry over unsold output and unsatisfied demand to future periods enables firms to keep actual output y close to the optimal point defined by (6). However, the more complete the detachment of y from y^d, the larger the buffer stocks required on average, which is either costly (iv) or likely to deter customers (uo). Optimizing behaviour thus implicates a *feedback* from buffer stocks to

[2] It is well-known that the empirical record of the *production smoothing model* is mixed. In particular, production has often been found to be more volatile than sales (Blinder, 1986) To reconcile the model with this finding, cost shocks and accelerator effects were introduced. But the extended model did still not perform well when overidentifying restrictions were tested with aggregate time series (Christiano and Eichenbaum, 1987; Miron and Zeldes, 1988). On the other hand, several studies using disaggregated data have supported the model (Ghali, 1987; Seitz, 1988; Rahiala and Terasvirta, 1988). Fair (1989) claims that previous negative results were due to unreliable data. A recent study for Swiss manufacturing based on survey data provides strong evidence for a buffer role of output inventories and unfilled orders (Etter, Nerlove and Willson, 1989). Nevertheless, the overall evidence for production smoothing looks rather ambiguous. Therefore, the model of this paper was estimated without buffer stocks as well; this version however turned out less successful empirically —see Stalder (1989b)— and is not reported here.

output. We postulate the feedback rule

$$y^{des} = \begin{cases} E(y^d)\left(\dfrac{iv}{iv*}\right)^{-\eta} & \text{(firms producing to stock)} \\ E(y^d)\left(\dfrac{uo}{uo*}\right)^{\eta} & \text{(firms producing to order),} \end{cases} \quad \eta > 0 \qquad (7)$$

where y^{des} is 'desired output' (to be distinguished from actual y, which may be subject to capacity or labour constraints). To keep things simple, the long term targets $iv*$ and $uo*$ are regarded as constants, and the feedback parameter η is assumed to be identical for both types of firms. According to (7), y^{des} basically follows the path of long-term expected demand, $E(y^d)$, and buffer stocks function as kind of an error correction term collecting past differences between actual demand and output.

Using assumption (6), we can replace $E(y^d)$ in (7) by $\widetilde{y}^s$ (3). To introduce now buffer behaviour into the firm model, we simply redefine x in (1) as

$$x = \frac{y^{des}}{\widetilde{y}^s} = \begin{cases} \left(\dfrac{iv}{iv*}\right)^{-\eta} \\ \left(\dfrac{uo}{uo*}\right)^{\eta}. \end{cases} \qquad (8)$$

3 Derivation of the aggregate model

Microeconomic equations are usually converted into aggregate relationships by invoking the concept of the representative firm. Transposing the above micro model directly to the macro level would however imply discrete switches of regimes for the economy as a whole that seem quite unrealistic. Considering the actual heterogeneity of the aggregate economy, one rather expects that situations of excess demand and excess supply in general coexist at the micro level so that transitions between regimes become gradual at the macro level. To capture this type of micro level diversity, we allow for *different* z and x ratios across *otherwise identical firms*. Assuming a large number of firms, we approximate the distribution of z and x by a continuous density

(3) This is not quite innocuous as demand expectations relevant to the output decision may involve a shorter time horizon than those relevant to the formation of production capacities. To the extent that the former are more volatile than the latter, specification (8) will overstate the degree of smoothing.

$g(z,x)$. Via (4), this defines a density of l and y across firms. On this basis, aggregate *employment* L and *output* Y can be expressed as[4]

$$L \;=\; nE(l) \;=\; n\tilde{l}^d E\left[\min(z,x^\gamma,1)\right] \;=\; \tilde{L}^d E\left[\min(z,x^\gamma,1)\right] \qquad (9.1)$$

$$Y \;=\; nE(y) \;=\; n\tilde{y}^s E\left[\min(z^\delta,x,1)\right] \;=\; \tilde{Y}^s E\left[\min(z^\delta,x,1)\right], \qquad (9.2)$$

where n is the number of firms, $\tilde{L}^d = n\tilde{l}^d$ is aggregate notional labour demand and $\tilde{Y}^s = n\tilde{y}^s$ aggregate notional goods supply (profitable capacities).

To obtain concrete expressions for L and Y, we assume that z and x are distributed *lognormally* and —although this is somewhat problematical— *independently* across firms:

$$\ln(z) \sim N\left(\mu_z,\sigma_z^2\right) \quad \text{and} \quad \ln(x) \sim N\left(\mu_x,\sigma_x^2\right). \qquad (10)$$

On this basis, (9) can be rewritten as

$$L \;=\; \tilde{L}^d \xi_1\left(\bar{z},\bar{x};\gamma,\sigma_z,\sigma_x\right) \qquad (11.1)$$

$$y \;=\; \tilde{Y}^s \xi_2\left(\bar{z},\bar{x};\delta,\sigma_z,\sigma_x\right), \qquad (11.2)$$

where $\bar{z} = E(z) = \exp(\mu_z + \sigma_z^2/2)$ and $\bar{x} = E(x) = \exp(\mu_x + \sigma_x^2/2)$.

The *proportions* of firms in the various *regimes* (to be measured by survey data) obtain as functions of the same distribution parameters. We concentrate here on the employment-weighted proportion of labour-constrained firms, $P_L(l^d > l^s)$, and the proportion of firms with $y^{des} > \tilde{y}^s$, $P_G(x > 1)$:

$$P_L \;=\; \xi_3\left(\bar{z},\bar{x};\gamma,\sigma_z,\sigma_x\right) \qquad (11.3)$$

$$P_G \;=\; \xi_4\left(\bar{x};\sigma_x\right) \;=\; \Phi\left(\frac{\mu_x}{\sigma_x}\right) \;=\; \Phi\left[\frac{\ln(\bar{x})}{\sigma_x} - \frac{\sigma_x}{2}\right] \qquad (11.4)$$

Function ξ_4 is given by the standard normal integral as stated in (11.4). ξ_1, ξ_2 and ξ_3 are more complicated numerical functions.

While the mean $\bar{z}$ can be equated to the ratio of aggregate labour supply to notional labour demand,

$$\bar{z} = E(z) = \frac{L^s}{\tilde{L}^d} \qquad (11.5)$$

[4] This aggregation procedure is inspired by Kooiman (1984) and Lambert (1988).

the derivation of the *mapping from Y^d to $\overline{x}$* requires some elaboration. According to (8), the individual x-values stem from two subsets of firms (producing to stock and order respectively). Lognormality of x across all firms thus implicates that $-\ln(iv/iv*)$ and $\ln(uo/uo*)$ have the same normal distribution in the two subsets, *i.e.*

$$-\ln(\frac{iv}{iv*}) \sim N(\mu,\sigma^2) \quad \text{and} \quad \ln(\frac{uo}{uo*}) \sim N(\mu,\sigma^2), \tag{12}$$

where $\mu = \mu_x/\eta$ and $\sigma = \sigma_x/\eta$. One implication of (12) that can be checked empirically by business survey data is

$$P_{iv<iv*} = P_{uo>uo*} = \Phi\left(\frac{\mu}{\sigma}\right).$$

The two proportions (inventories "too small', unfilled orders "too large') in fact show quite similar developments over time in the estimation period 1967Q2 to 1985Q4 ($R^2 = 0.81$, RMS–difference 0.06). This constitutes some evidence in favour of assumption (12). As the two subgroups of firms are of about equal size, we shall proxy $P_G(x > 1)$ in (11.4) empirically as[(5)]

$$P_G = \frac{P_{iv<iv*} + P_{uo>uo*}}{2}. \tag{13}$$

As firms are assumed to be identical with respect to the targets $iv*$ and $uo*$, $E(iv/iv*)$ and $E(uo/uo*)$ correspond to the aggregate ratios $IV/IV*$ and $UO/UO*$. From (12) thus follows

$$IV/IV* = \exp\left(-\mu + \frac{\sigma_2}{2}\right) \quad \text{and} \quad UO/UO* = \exp\left(\mu + \frac{\sigma^2}{2}\right).$$

Combining these two equations we may write

$$\left[\frac{\ln\frac{UO}{UO*} - \ln\frac{IV}{IV*}}{2}\right] = \mu = \frac{\mu_x}{\eta} = \left[\frac{\ln \overline{x}}{\sigma_x} - \frac{\sigma_x}{2}\right]\frac{\sigma_x}{\eta}. \tag{14}$$

Assuming $UO* = IV*$ and constant over time, adopting a first order approximation ($\ln a \cong a - 1$ near $a = 1$) and condensing the various constants into k, we get the following relationship between 'aggregate buffer stocks' BU and $\overline{x}$:

$$BU = U0 - IV = k\left[\frac{\ln \overline{x}}{\sigma_x} - \frac{\sigma_x}{2}\right], \quad k > 0. \tag{15}$$

(5) The concrete derivation of these proportions from the KOF-ETH survey is described in Stalder (1989a), section 3.3.

Aggregation of (5) on the other hand yields:

$$BU = BU_{-1} + Y^d_{-1} - Y_{-1}. \tag{16}$$

Equations (16) and (15) define the mapping from Y^d (via BU) to $\overline{x}$.

For the aggregate demands and supplies, we shall specify below econometric equations. The corresponding dependent variables $(Y^d,\widetilde{Y}^s,\widetilde{L}^d,L^s)$ are unobserved[(6)]. However, (15), (16) and (11) *transform* $(Y^d,\widetilde{Y}^s,\widetilde{L}^d,L^s)$ *one-to-one* to the observables (Y,L,P_L,P_G). In principal, we can thus estimate the parameters of the econometric equations in the framework of this mapping along with the transformation parameters $(\sigma_x,\sigma_y,\gamma,\delta,k)$ by maximum likelihood.

The *working* of the transformation is intuitively quite obvious. The functions ξ_1 and ξ_2 in (11.1) and (11.2) are the smooth aggregate counterparts to the micro-level min-conditions in (4). They show to what extent aggregate employment L and output Y get reduced relative to firms' notional trade offers $\widetilde{L}^d$ and $\widetilde{Y}^s$ due to low $\overline{z} = L^s/\widetilde{L}^d$ (insufficient labour supply) and low $\overline{x}$ (small unfilled orders, large inventories). For increasing $\overline{z}$ and $\overline{x}$, both ξ_1 and ξ_2 converge from below to 1, while ξ_3 in (11.3) goes asymtotically to 0 and ξ_4 in (11.4) tends to 1; in the limit we have 'pure' Classical unemployment ($L = \widetilde{L}^d$, $Y = \widetilde{Y}^s$, $P_L = 0$, $P_G = 1$). If we let $\overline{z}$ assume progressively smaller values, P_L tends to 1 while ξ_1 converges to $\overline{z}$ so that we approach $L = \widetilde{L}^d\overline{z} = L^s$.

What is the role of the dispersion parameters σ_z and σ_x? Large σ_z and σ_x, *i.e.* strongly differing z and x-values across firms, increase the smoothness of the transition between regimes. Further, ξ_1 and ξ_2 and thus L and Y are decreasing functions of σ_z and σ_x, reflecting *structural mismatch*.

The following reformulations will simplify estimation considerably. First, inverting (11.4) and combining it with (15), we can eliminate $\overline{x}$, obtaining

$$k\Phi^{-1}(P_G) = BU.$$

$k\Phi^{-1}(P_G)$ is a proxy for unobserved BU; hence (16) can be restated as

$$k\Phi^{-1}(P_G) = k\Phi^{-1}(P_{G_{-1}}) + Y^d_{-1} - Y_{-1}, \tag{17.1}$$

mapping lagged differences between latent demand Y^d and output Y onto P_G. As P_G according to (11.4) increases monotonically with $\overline{x}$,

[(6)] If reliable data for aggregate buffer stocks BU were available, one could infer Y^d from (16); unfortunately, such data are not at hand in Switzerland.

we can replace $\bar{x}$ by P_G in (11.1), (11.2) and (11.3) as well. Further inserting $L^s/\widetilde{L}^d$ for $\bar{z}$, we get:

$$L = \widetilde{L}^d\psi_1\left(\frac{L^s}{\widetilde{L}^d}, P_G; \gamma, \sigma_z, \sigma_x\right) \quad (17.2)$$

$$Y = \widetilde{Y}^s\psi_2\left(\frac{L^s}{\widetilde{L}^d}, P_G; \delta, \sigma_z, \sigma_x\right) \quad (17.3)$$

$$P_L = \psi_3\left(\frac{L^s}{\widetilde{L}^d}, P_G; \gamma, \sigma_z, \sigma_x\right). \quad (17.4)$$

For given P_G, predetermined in (17.1), equations (17.2) to (17.4) establish a one-to-one mapping from $(\widetilde{Y}^s, \widetilde{L}^d, L^s)$ —or the error terms of the corresponding econometric equations— to (Y, L, P_L). However, as this transformation involves several complicated integrals that can be computed only numerically, we adopt a convenient *closed-form approximation* similar to the one proposed by Lambert (1988) in a related context. Restating (17.1) as (18.1) and denoting deterministic parts of econometric equations by 'hats', this approximation reads as:

$$k\Phi^{-1}(P_G) - k\Phi^{-1}(P_{G_{-1}}) + Y_{-1} = Y^d_{-1} = \widehat{Y}^d_{-1} + ku_1 \quad (17.5)$$

$$Y(1-P_L)^{-\alpha_Y} = Y^{sp} = \widehat{\widetilde{Y}^s} P_G^{\kappa_Y} e^{u_2} \quad (17.6)$$

$$L(1-P_L)^{-\alpha_L} = L^d = \widehat{\widetilde{L}^d} P_G^{\kappa_L} e^{u_3} \quad (17.7)$$

$$LP_L^{-\alpha_L} = L^s = \widehat{L}^s e^{u_4}, \quad (17.8)$$

with $k, \alpha_Y, \alpha_L, \kappa_Y, \kappa_L > O$.

System (18) links the econometric demand and supply equations to the observable endogenous variables (realized levels of output and employment L, rationing proportions P_L and P_G). The working of this transformation and its relationship to the exact mapping (17) can be clarified as follows:

a) If we let Y^d_{-1} increase sufficiently beyond Y_{-1} in (18.1), P_G will tend to 1 (all firms have 'too small' inventories or 'too large' unfilled orders). In the limit, planned output supply Y^{sp} and effective labour demand L^d in (18.2) and (18.3) converge to the notional trade offers, $\widetilde{Y}^s$ and $\widetilde{L}^d$. To the extent that P_G is smaller than

1, reflecting the presence of excessive inventories and insufficient unfilled orders in the population of firms, Y^{sp} and L^d will get reduced relative to the notional trade offers (Keynesian spillover). To generate the empirical productivity cycle, corresponding to the restriction $\gamma < 1$ in the exact model, we must have $\kappa_L < \kappa_Y$.

b) On the labour market, effective labour demand L^d meets a certain supply L^s. To show how P_L (proportion of firms constrained by labour supply) is determined, we divide (18.3) by (18.4), yielding the 'reduced form'-expression

$$\left[\frac{P_L}{1-P_L}\right]^{\alpha_L} = \frac{\widetilde{L}^d P_G{}^{\kappa_L}}{L^s} \quad \left(\text{where } \widetilde{L}^d = \widehat{\widetilde{L}}^d e^{u_3}\right). \tag{19}$$

P_L is a logit-type function of the demand/supply ratio, tending to 1 (0) for increasing (decreasing) effective demand $L^d = \widetilde{L}^d P_G{}^{\kappa_L}$. This function mimics the basic properties of (17.4). Parameter α_L measures the micro dispersion with respect to l^s/l^d, l^d being effective labour demand[7].

c) According to (19), increasing L^s pushes P_L towards 0. If at the same time $P_G \to 1$, we have a limiting situation of 'pure' classical unemployment, and (18.2) and (18.3) imply $L \to \widetilde{L}^d$ and $Y \to \widetilde{Y}^s$. This is of course also the basic behaviour of (17.2) and (17.3).

d) Suppose that the demand/supply ratio on the labour market is such that a certain proportion of firms is constrained by labour supply $(0 < P_L < 1)$. The resulting rationing of employment L in relation to L^d is captured in (18.3) by the term $(1 - P_L)^{\alpha_L}$. The associated 'repressed inflation' spillover onto output Y in relation planned output supply Y^{sp} in (18.2) is accounted for by $(1-P_L)^{\alpha_Y}$. Consequently, the restriction $\delta < 1$ of the exact model (concave production function) implies $\alpha_Y < \alpha_L$.

e) Setting L^s equal to L^d (aggregate labour market equilibrium), (18.4) and (19) imply $P_L = 0.5$, $L/L^s = 0.5^{\alpha_L}$ and $(L^s - L)/L^s = 1 - 0.5^{\alpha_L} > 0$. Adopting the terminology of Sneessens and Drèze (1986), we call this unemployment rate SURE (structural unemployment rate at equilibrium). It measures unemployment that arises from the *structural mismatch* of demand and supply at the

[7] According to (1), l^d depends on $\widetilde{l}^d$ as well as on x^γ. Therefore α_L not only takes the role of parameter σ_x of the exact model (dispersion of $l^s/\widetilde{l}^d$) but also reflects σ_x and γ. This is increasingly the case if $\overline{x}$ is low. Consequently, treating α_L as a constant is somewhat problematical.

micro level. SURE is positively related to parameter α_L. As empirical studies for several countries have found evidence for a *growing* mismatch, we introduce some flexibility in this respect as well and reparametrize

$$\alpha_L = \alpha_0 e^{\nu t} \qquad \alpha_Y = \alpha_L \tau = \alpha_0 e^{\nu t}\tau. \tag{20}$$

Instead of α_L and α_Y we thus estimate α_0, ν and τ. Growing mismatch shows up as $\nu > 0$, and the restriction $\alpha_Y < \alpha_L$ is translated into $\tau < 1$.

So far, the productivity cycle (labour hoarding) is accounted for in (18) in a "static' manner (restriction $\kappa_L < \kappa_Y$). A dynamic alternative to this is:

$$Y(1-P_L)^{-\alpha_Y} = Y^{sp} = \left[\widehat{\widetilde{Y}^s} P_G{}^{\kappa}\right]^{\lambda_Y} Y_{-1}^{sp\,(1-\lambda_Y)} e^{u_2} \tag{18.2'}$$

$$L(1-P_L)^{-\alpha_L} = L^d = \left[\widehat{\widetilde{L}^d} P_G{}^{\kappa}\right]^{\lambda_L} L_{-1}^{d\,(1-\lambda_L)} e^{u_3} \tag{18.3'}$$

with $0 < \lambda_L < \lambda_Y < 1$.

These equations, replacing (18.2) and (18.3), impose $\kappa_L = \kappa_Y = \kappa$ but allow for different dynamic adjustment speeds λ_Y and λ_L.

4 Specification of the aggregate econometric equations

In the following we develop the aggregate demand and supply equations. We put the emphasis on a careful representation of the production sector while keeping the specification of labour supply and goods demand simple.

4.1 Labour supply

Labour supply is specified exactly as in Stalder (1989a). For labour supply of *Swiss residents* we postulate[8]:

$$\widehat{L}^s_{SW_t} = d_1\, POP_t\, e^{d_2 t} wr*_t^{d_3}\, wr_t^{d_4}, \tag{21}$$

$$d_4 > 0 \text{ (elasticity of intertemporal substitution)}.$$

[8] Henceforth, we index variables by the time subscript t.

POP is the potential labour force (Swiss residents, age 16 to 64), wr is 'net real wage' (nominal wage after taxes, deflated by CPI), $wr*$ is 'permanent' wr. The term d_2t is to capture trend factors like increasing female labour force participation, longer periods of education, earlier retirement etc. The formation of $wr*$ is modelled adaptively as:

$$wr*_t = wr_t^{d_5} wr*_{t-1}^{(1-d_5)} = wr_t^{d_5} wr_{t-1}^{d_5(1-d_5)} wr_{t-2}^{d_5(1-d_5)^2} \ldots, 0 < d_5 < 1.$$

A Koyck-transformation eliminates $wr*$ from (21).

To obtain total labour supply, we multiply Swiss labour supply by a 'foreign worker factor':

$$\widehat{L}_t^s = \widehat{L}_{SW_t}^s \,(1 + RFS_t)\,, \tag{22}$$

where RFS_t is the observed ratio of foreign to Swiss employment (implying identical unemployment rates for Swiss and foreign workers). RFS_t will be treated as weakly exogenous. This is probably not fully adequate as immigration may have responded, even within the period, to labour market conditions.

4.2 Demand for domestic output

Demand for domestic output Y^d (more precisely: demand for value-added produced by domestic firms) can be viewed as being determined by (a) the development of *total demand* on domestic and foreign markets and (b) the *relative share* in these markets taken by Swiss firms.

(a) In the specification of *domestic demand*, we separate out firms' investment demand, I^d (gross fixed business investment). I^d plays an important role on the production side of the model and will be specified there in connection with labour demand and output supply. For the rest of domestic demand, D^d (consumption, residential construction, government demand), we simply posit a positive impact of 'aggregate income' Y and a negative impact of the real interest rate i^r (defined in section 4.3 below):

$$D^d = D^d(\underset{+}{Y},\ \underset{-}{i^r}). \tag{23.1}$$

The development of *foreign demand* F^d is explained by a weighted index of GDP in Switzerland's major trading partners, denoted by Y^F:

$$F^d = F^d(\underset{+}{Y^F},\ \underset{+}{\Delta Y^F}). \tag{23.2}$$

ΔY^F is included as foreign investment demand, accounting for about 45% of Swiss exports, can be expected to be related to changes in foreign activity.

(b) The allocation of I^d,D^d and F^d to Swiss and competing foreign firms is governed by relative prices. To keep things as simple as possible, we apply to all markets the same price ratio p/p^F with an identical elasticity a_6.[(9)] Assuming that (23.1) and (23.2) are linear and further introducing a partial adjustment mechanism, we specify 'demand for domestic output' as

$$\begin{aligned} \widehat{Y}_t^d \quad = \quad & \lambda_G \left(a_O + a_1 Y_{t-1} + a_2 i_{t-1}^r + a_3 I_t^d + a_4 Y_t^F \right. \\ & \left. + a_5 \Delta Y_t^F\right) \left(\frac{p}{p^F}\right)_t^{a_6} + (1-\lambda_G) Y_{t-1}^d \qquad (24) \\ & a_1, a_3, a_4, a_5 > 0, \quad a_2, a_6 < 0, \quad 0 < \lambda_G < 1. \end{aligned}$$

To account for some extra inertia in consumption, government and residential construction demand, explained in (24) by Y and i^r, a one-quarter lag has been introduced for these variables.

By the inclusion of lagged Y as explanatory variable, (24) entails Keynesian multiplier effects. However, as we do not equate Y^d with Y but take into account that Y may be subject to supply constraints, the size of the multiplier depends on the rationing situation, being largest if both P_G and P_L are low (predominant Keynesian unemployment).

4.3 Notional labour demand, notional goods supply and investment

We turn now to the production sector and develop the equations for investment demand, notional goods supply and notional labour demand. Adopting a *putty-clay vintage framework*, we describe the evolution of the production apparatus through time in terms of investment in new equipment and scrapping of old equipment. In such a setting, notional goods supply and notional labour demand can be "updated' from period to period by

$$\widehat{\widetilde{Y}}_t^s = \widetilde{Y}_{t-1}^s F_t^Y + Y_t^\Delta \qquad \text{and} \qquad \widehat{\widetilde{L}}_t^d = \widetilde{L}_{t-1}^d F_t^L + L_t^\Delta, \qquad (25)$$

[(9)] Considering several alternatives, we decided to measure p/p^F on basis of 'relative export unit values' (*IMF*, International Financial Statistics). Weights are designed to capture the relative importance of Switzerland's main competitors on home, foreign and third countries' markets.

where Y_t^Δ and L_t^Δ are output and labour input on equipment newly installed in period t and F_t^Y and F_t^L are 'scrapping factors' generally assuming values of somewhat less than 1.

Y_t^Δ and L_t^Δ are related to I_t, gross investment of period t, by an 'ex ante' production function subject to Hicks-neutral technical progress:

$$Y_t^\Delta = G(L_t^\Delta, I_t)e^{\beta_2 t} = I_t g(L_t^\Delta / I_t)e^{\beta_2 t}, \quad g' > 0, \quad g'' < 0. \tag{26}$$

Malinvaud (1987), analysing firms' investment decision under conditions of irreversibility and demand uncertainty, shows that the optimal *production capacity* depends —besides expected demand— on profitability, the reason being that high profitability makes it worthwhile for firms to take a greater risk of ending up with excess capacities, while the optimal *capital-labour* ratio is mainly determined by relative factor costs[10]. On this basis —and adopting convenient functional forms— we postulate:

$$\left[\frac{L^\Delta}{I}\right]_t = c_1 \left[\frac{w}{uc}\right]_t^{-c_2} \qquad c_1, c_2 > 0 \tag{27.1}$$

$$\left[\frac{Y^\Delta}{I}\right]_t = b_1 \left[\frac{w}{uc}\right]_t^{-b_2} e^{\beta_2 t} \qquad b_1, b_2, \beta_2 > 0 \tag{27.2}$$

$$Y_t^\Delta = Y^\Delta(DP_t, PFT_t). \tag{27.3}$$

DP_t and PFT_t stand for 'demand pressure' and 'profitability', as suggested by Malinvaud's study; the concrete form of (27.3) will be specified below. In (27.1) and (27.2) w is nominal wage and uc is user cost of capital defined as

$$uc = p_c(\xi + i^r) \qquad \text{with} \qquad i^r = i - \dot{p}^e,$$

where p_c is the price of investment goods, ξ is a constant depreciation rate (set to 0.1 per year), i is the long-term interest rate, and $\dot{p}^e$ the 'expected inflation rate', specified as a weighted average of actual inflation over past 12 quarters as proposed by Ando et *al.* (1974). Parameter c_2 corresponds to the substitution elasticity of the 'ex ante' production function (26).

Taken together, equations (27) determine L^Δ, I and Y^Δ (labour, capital and capacity output associated with a new vintage) conditional

[10] In addition, as capital is irreversible, the capital intensity is negatively related to demand uncertainty. See also Lambert and Mulkay (1986).

on DP, PFT and w/uc. This system can be recast in various tantamount ways. With regard to estimation, note that the determination of Y^{Δ} in (27.3) is likely to involve a large error since we cannot expect to find a precise econometric representation of firms' "scale decision' (animal spirits). Technical ratios like L^{Δ}/I or Y^{Δ}/I on the other hand presumably are much easier to model. This suggests that we specify L^{Δ} and Y^{Δ} conditional on observed I, capturing the scale component, and enclose (27.3) in the investment equation[11]:

$$L_t^{\Delta} = c_1 I_t \left[\frac{w}{uc}\right]_t^{-c_2} \tag{28.1}$$

$$Y_t^{\Delta} = b_1 I_t \left[\frac{w}{uc}\right]_t^{-b_2} e^{\beta_2 t} \tag{28.2}$$

$$I_t = Y_t^{\Delta}(DP_t, PFT_t) b_1' \left[\frac{w}{uc}\right]_t^{b_2} e^{-\beta_2 t}. \tag{28.3}$$

For $Y^{\Delta}(DP,PFT)$, to be substituted into (28.3), we postulate :

$$Y_t^{\Delta} = Y_t \underbrace{\left[e_1 + e_2 \Phi^{-1}(P_{G_t})\right]}_{DP} \exp\underbrace{\left\{e_3 \left[\ln \frac{(w/p)_t}{(w/p)_0} - \beta_3 t\right]\right\}}_{PFT} \tag{29}$$

$$e_2,\ \beta_3 > 0;\ e_3 < 0.$$

The *profitability term* PFT posits that, due to technical progress, profitability on new equipment remains unchanged over time if the real wage w/p increases with a rate β_3. Deviations of w/p from this implicit trend entail inverse changes in profitability ($e_3 < 0$). PFT reflects wage costs and costs of material inputs (as p is price of value added); attempts to include capital costs were empirically unsuccessful. The *pressure of demand term*, DP, arises from averaging the log of $x = y^{des}/\tilde{y}^s$ across firms: $E[\ln(x)] = \sigma_x \Phi^{-1}(P_G)$, where P_G is the proportion of firms with $x > 1$; see (10) and (11.4). Parameter e_2 comprises σ_x. As DP is in relative terms, we finally multiply by Y.

---

[11] The model treats *technical progress* in a rather restrictive manner. All technical change is assumed to be *embodied*. Moreover, it is introduced in (26) in such a way that the shape of the isoquants and thus the optimal *labor intensity* L^{Δ}/I remain *unaffected* while capital productivity Y^{Δ}/I as well as labor productivity Y^{Δ}/L^{Δ} are enhanced. Hence technical progress does not show up in labor demand (conditional on capital I) but exerts a negative impact on investment (conditional on capacity Y^{Δ}). Of course, there is a positive influence of technical progress on investment via PFT in (28.3), and this effect will prove dominant empirically. A more general treatment of technical progress seems desirable but is beyond the scope of this paper.

We insert now (29) into (28.3). To account for various probable lags (perception, formation of expectations, decision, installation), we backshift the explanatory variables one quarter, augment the investment equation by a partial adjustment scheme and adapt (28.1) and (28.2) accordingly[12]:

$$\begin{aligned} I_t^* &= Y_{t-1}\left[e_1 + e_2\Phi^{-1}(P_{G_{t-1}})\right]\exp\left\{e_3\left[\ln\frac{(w/p)_{t-1}}{(w/p)_0} - \beta_3 t\right]\right\}\left[\frac{w}{uc}\right]_{t-1}^{b_2} e^{-\beta_2 t} \\ \widehat{I}_t &= \lambda_I I_t^* + (1-\lambda_I)I_{t-1} \end{aligned} \tag{30}$$

$$L_t^{\Delta} = c_1 I_{t-1}\left[\frac{w}{uc}\right]_{t-2}^{-c_2} \tag{31}$$

$$Y_t^{\Delta} = b_1 I_{t-1}\left[\frac{w}{uc}\right]_{t-2}^{-b_2} e^{\beta_2 t}\,. \tag{32}$$

Turning now to the *scrapping factors* F_t^L and F_t^Y in (25), we assume that the production apparatus consists of "machines' distributed on a continuum of labour productivities (value-added per unit of labour), describable by means of a continuous density $f(\pi)$. In each period, firms have to decide down to which 'marginal' productivity level $\pi_t^{\min}$ they can operate existing machines profitably. Integrals over $f(\pi)$, starting at the lower limit $\pi_t^{\min}$, define the set of machines still in use in period t. To take into account efficiency loss on existing equipment, we allow for a proportional shift in density $f(\pi)$ towards lower productivities by a factor $(1-s)$ each period, s being a small positive constant. Defining $\pi_t = \pi_t^{\min}/\pi_{t-1}^{\min}$ (relative increase in marginal productivity), the following expressions for F_t^L and F_t^Y can be derived:

$$F_t^L = 1 - r\left[\frac{\pi_t}{1-s} - 1\right] \tag{31.1}$$

$$r, s, q > 0$$

$$F_t^Y = (1-s)\left\{1 - qr\left[\frac{\pi_t}{1-s} - 1\right]\right\}\cdot \tag{31.2}$$

To clarify the working of these specifications, suppose that firms choose to reduce marginal productivity just by factor $(1-s)$ so that $\pi_t/(1-s) = 1$. This amounts to the decision to carry over all machines operated in period $t-1$ to period t. In this case, (31.1) implies $F^L = 1$. Accordingly, there is no reduction in notional labour demand in (25). However, as labour productivity on all machines has dwindled by factor $(1-s)$,

[12] b_1' becomes redundant, *i.e.* is included in e_1 and e_2.

notional output supply must fall by $(1-s)$. This is exactly what (31.2) says. For higher π_t, F^L falls below 1; the effect is parameterized by r, which can roughly be viewed as an elasticity. The corresponding output elasticity is weaker since value-added per unit of labour on marginal machines is below average. This is taken into account by parameter q, set to a value of 0.6 in the empirical application (corresponding to the labour share in value-added).

Under *perfect competition*, machines are operated as long as they yield positive quasi rents. The optimal scrapping point is thus reached (a) when unit labour costs equal the price or —an equivalent definition— (b) when labour productivity equals the real wage. This suggests defining π_t in (31) as

$$\pi_t = \frac{\pi_t^{\min}}{\pi_{t-1}^{\min}} = \frac{(w/p)_t}{(w/p)_{t-1}}. \tag{32}$$

Under any form of *imperfect competition* it may be optimal to replace old machines by new ones even if they still yield positive quasi rents. In terms of formulation (a) above, firms determine scrapping by comparing unit labour costs on old machines not to price p but to total unit costs on new machines (TUC). Accordingly, one should replace p in (32) by TUC and relate TUC to investment in new equipment. To keep things simple, we however assume a constant mark-up of p over TUC so that we may stick to (32)[13].

5 Structure of the model and method of estimation

In order to estimate the structural equations of the preceding section, we link them to observables via transformation (18); in detail:

- The *vintage equations* (30.2) and (30.3), determining employment and output on vintage t, and the *scrapping functions* (31.1) and (31.2), where π_t is given by (32), are inserted into the updating definitions for *notional goods supply* and *notional labour demand*, (25), which in turn are linked by (18.2') and (18.3') to observables.

[13] As TUC refers to costs on new (most efficient) machines whereas p can be expected to reflect average costs on all machines, the assumption of a constant mark-up of p over TUC is rather problematical. Moreover, as sales (and the supplies of input factors) are not unlimited at going prices under imperfect competition, there will be complex interactions between the investment decision and the scrapping of old equipment that are not appropriately accounted for by our specification.

- The equation explaining *demand for domestic output*, (24), is related by (18.1) to observables.
- *labour supply* of Swiss residents, (21), is augmented in (22) by foreign workers and connected then via (18.4) to observables.

Ideally, one should like to estimate the *investment equation* (30.1), substituted into aggregate demand (24), in the framework of (18.1). While feasible for a simple specification of investment demand, such a procedure would lead to a hopeless overparametrization of aggregate demand for the sophisticated specification of investment behaviour proposed in (30.1). We are thus forced to estimate (30.1) detached from the buffer mechanism (18.1) by directly using realized investment as dependent variable:

$$I_t = \widehat{I}_t + u_{5t}. \tag{33}$$

Accordingly, we also replace I_t^d in (24) by observed I_t. The neglect of possible short-term differences between investment demand and actual investment (giving rise to changes in unfilled orders) can be considered a minor flaw in view of an import share of about 70% and a contribution of investment demand to total demand for domestic output of only 6%[(14)].

The model contains five stochastic *observable endogenous variables*: Y(real GDP), L (aggregate employment), proportions P_L and P_G, and investment I (gross fixed business investment). As *explanatory variables*, econometrically treated as *weakly exogenous*, we have: w(nominal wage), p (GDP-deflator), uc (user cost of capital), t (time), i^r (real interest rate), Y^F (weighted foreign GDP), p^F (foreign price index), POP (potential labour force), wr (net real wage), RFS (ratio of foreign to Swiss employment). The remaining variables of the model, in particular the latent demands and supplies appearing in (18), obtain as functions of observables and unknown parameters.

Joint estimation of the model by *maximum likelihood* is advisable because of cross-equation restrictions, contemporaneously correlated errors and simultaneous endogenous variables. *Cross-equation restrictions* show up in form of parameters $a_0, \nu, \kappa, b_2, \beta_2, r$ and s. *Contemporaneous correlation* of error terms must be expected especially with respect to u_{2t}, u_{3t} and u_{5t} since (30.1), (30.2) and (30.3) as well as (31.1) and (31.2) are likely to involve substantial common specification

(14) Distinguishing between I^d and I would complicate things a lot. One would then have to specify how total excess demand, $Y^d - Y$, is distributed between the various demand components, since in the vintage equations (30.2) and (30.3) it is actual I and not I^d that matters.

errors. Concerning the *simultaneity* of endogenous variables, note that the lag of investment in the vintage equations (30.2) and (30.3) is to be interpreted as a technical delay in installation and does not make firms' *decision* on investment in (30.1) predetermined with respect to L_t^{Δ} and Y_t^{Δ}. Firms will rather decide simultaneously on capital, labour input and output of a new vintage. Hence (30.1) is estimated, one period lagged, jointly with the other equations. To set up the likelihood function we take $u_t' = (u_{1t}, u_{2t}, u_{3t}, u_{4t}, u_{5t})$ to be i.i.d. normal with covariance matrix Ω. The Jacobian of transformation from u_t to the observable endogenous variables $(I_{t-1}, Y_t, L_t, P_{G_t}, P_{L_t})$, defined by (18), is

$$
\begin{aligned}
|\det J_t| &= \left[\frac{\partial \Phi^{-1}(P_G)}{\partial P_G}\right]_t \frac{\alpha_0 e^{\nu t}}{Y_t L_t P_{L_t}(1 - P_{L_t})} \\
&\text{or} \\
\ln|\det J_t| &= C_t + \nu t + \ln(\alpha_0),
\end{aligned}
\qquad (34)
$$

where Ct collects all terms not dependent on unknown parameters.

Estimation may be simplified by exploiting the fact that P_G reflecting beginning-of- period buffer stocks, according to (18.1) and (24) solely depends on lagged values of demand and output. As u_1, can be shown to be independent of the other error terms (by testing the corresponding constraints on Ω), and as no cross-restrictions with the rest of the model are involved, the likelihood function factorizes in such a way that goods demand (24), inserted into (18.1), and the rest of the model can be estimated as separate blocks (weak exogeneity). Estimation of goods demand simply amounts to minimizing the sum of squared residuals in (18.1). The conditional log-likelihood of all remaining equations is maximized using the Davidon-Fletcher-Powell algorithm as implemented in GQOPT [Quandt (1983)]. Standard errors of the parameter estimates are derived from the approximate inverse of the Hessian. The estimation period is 1967Q2 to 1985Q4.

6 Estimation results

6.1 Demand for domestic output

Transformation (18.1) derives unobserved 'demand for domestic output' Y^d from observed output Y and $k\Phi^{-1}(P_G)$. The latter term serves as a proxy for 'aggregate buffer stocks' BU (unfilled orders minus output inventories), for which reliable direct information is unavailable in Switzerland. The calibration of scaling parameter k turns out to be delicate though. The attempt to estimate k simultaneously with the various demand parameters in (24) does not work out well. It implies unrealistically large buffer stocks and also leads to implausible parameter estimates in (24). We are thus forced to fix k at a value that appears realistic in the sense that the implied developments of BU and Y^d look plausible when compared to Y. Setting $k = 6000$, the resulting standard deviation of ΔBU amounts to 2% of Y in the sample period, and the standard deviation of ΔY^d exceeds that of ΔY by a factor of 1.2. These are quite plausible implications. Conditional on $k = 6000$ we also get parameter estimates in (24) that look reasonable by and large (see summary table).

Summary of the estimation results

(standards errors in parenthesis, insignifiance at 5%-level indicated by *)

Transformation parameters (mismatch and spillovers)	α_0	.0142	ν	.0115	τ	.538	κ	.154
		(.00344)		(.00450)		(.250)		(.0188)
Demand for domestic output	a_1	.686	a_2	−132.	a_3	.0357*	a_4	88.1
		(.163)		(63.0)		(.441)		(34.2)
	a_5	480.	a_6	−.0920*	λ_G	.716		
		(169.)		(.0707)		(.157)		
Notional output supply, notional labor demand, and investment	b_1	.418	b_2	.345	β_2	.00218		
		(.0411)		(.0686)		(.000543)		
	c_1	.0280	c_3	.660	r	.525	s	.0305
		(.00908)		(.108)		(.188)		(.0032)
	e_1	.171	e_2	.0777	e_3	−2.76	β_3	.00651
		(.0112)		(.0225)		(.942)		(.00041)
	λ_Y	.681	λ_L	.278	λ_I	.207		
		(.0948)		(.0554)		(.0753)		
Labor supply	d_2	−.00390	d_3	.225*	d_4	.150*	d_5	.113*
		(.00131)		(.226)		(.112)		(.0608)

Residuals		$\hat{u}_1$	$\hat{u}_2$	$\hat{u}_3$	$\hat{u}_4$	$\hat{u}_5$
	SER	.0559	.0155	.0075	.0081	122.4
	DW	1.95	1.64	1.36	1.76	2.24

Parameter a_1, the 'marginal propensity to consume out of GDP' (including government spending and residential construction), assumes a plausible value of about 0.7. The estimate for a_3, measuring the contribution of investment to demand for domestic output, seems too low; but a sensible value certainly lies within the wide confidence interval. The elasticity of Y^d with respect to p/p^F, a_6, is surprisingly weak. Parameters a_2, a_4 and a_5 are all quite plausible, which can be seen by computing the impacts of the associated variables on Y^d at the sample means(15): if the real interest rate increases by 1% point, Y^d falls by about 0.5%; a 1%-increase in Y^F (foreign GDP) entails a 0.32%-rise in Y^d; an acceleration in the growth of Y^F by 1% leads to a 1.7%- increase in Y^d. All these parameter values refer to the long run. According to λ_G short-run adjustment is quite rapid.

As these estimates look reasonable by and large, we could be quite pleased if the SSR was flat along the k-axis. But SSR actually decreases strongly for growing k, and the restriction $k = 6000$ is clearly rejected ($F = 20.4$). This indicates that the specification of goods demand and/or the form of the buffer mechanism need improvement, a task that must be left to future work though.

6.2 Transformation parameters (mismatch and spillovers)

All remaining equations of the model are estimated simultaneously in the framework of transformations (18.2'), (18.3') and (18.4). The transformation parameters, listed in the summary table, have the following interpretations.

According to the estimate obtained for $\alpha_L = \alpha_0 e^{\nu t}$, *structural unemployment* ($SURE$) has risen from 0.98% in the late 60s to 2.28% in 1985, indicating a considerable micro-level mismatch in recent years. This finding contrasts with Switzerland's much lower official unemployment rates (see section 7.2).

The *repressed inflation spillover*, parametrized by α_L and τ can be demonstrated by assuming an aggregate labour market equilibrium and letting L^s decrease then by 1%. Setting α_L to its sample mean, this produces declines in employment L and output Y of 0.56% and 0.34% respectively.

To visualize the *Keynesian spillover*, we assume that firms enter period $t-1$ with zero 'aggregate buffers', *i.e.* $BU_{t-1} = UO_{t-1} - IV_{t-1} = 0$, implying $P_{G_{t-1}} = 0.5$, and are facing during that period a demand which falls short of output by 1%. Firms will thus move into period t

(15) Y, I and Y^d are measured in millions of Swiss Francs at prices of 1970 and have sample means of 24185, 3417 and 24965 respectively; the price ratio p/p^F is 1 in 1970 and has a sample mean of 1.43; the real interest rate i^r is measured in percentage points; Y^F (foreign GDP) is an index (1980=100) with a sample mean of 89.3.

with lower BU, implying by (18.1) a drop in P_G from 0.5 to 0.484. On basis of the estimate of κ we may infer from (18.2') and (18.3') that output supply and labour demand both fall by about 0.5% in the long-run. The short-run reductions, according to λ_Y and λ_L, are 0.34% and 0.14% respectively.

6.3 Notional labour demand, notional output supply, and investment

Parameter c_2 in (30.2), the 'ex ante'-elasticity of substitution, assumes a plausible value of 0.66. The value obtained for c_1, saying that 28 new jobs were created per investment outlays of 1 million SFr. in 1970, seems a bit high (note that w/uc is normalized to 1 in this period). Parameter b_1 in (30.3), measuring output per unit of new capital in 1970, is probably also overestimated. The elasticity of I/Y^{Δ} with respect to $w/uc, b_2$, is —as expected on theoretical grounds— smaller than c_2. The rate of technical progress on new equipment, β_2, assumes a value of 0.218% per quarter, which seems too low.

Another measure of technical progress is provided by parameter β_3 in the investment equation (30.1); it says that a quarterly real wage growth of 0.651% leaves profitability on new equipment unchanged. According to e_3, deviations of actual w/p from this trend affect investment with an elasticity of -2.76, emphasizing the importance of profitability. To discuss the impact of 'demand pressure' on investment, we set $P_G = 0.5$ and let Y^d exceed actual Y by 1% at the sample mean of Y. As a result, $\Phi^{-1}(P_G)$ according to (18.1) increases from 0 to 0.0403, and the values of e_1 and e_2 imply that I^* rises by 1.8%. The long-term elasticity of investment with respect to Y^d is thus about 1.8, which seems reasonable. According to the value obtained for λ_I, about half of a certain long-term change is completed within 3 quarters.

Parameter r in (31.1) measures the impact of real wages on notional labour demand due to *scrapping* of old equipment. The value of 0.525, which roughly can be interpreted as an elasticity, seems plausible. According to the value of s, productivity on existing plants deteriorates by 3.05% per quarter, implying scrapping factors $F_t^L = 0.983$ and $F_t^Y = 0.960$ at $(w/p)_t = (w/p)_{t-1}$. In other words, if the real wage remains constant and no new equipment is installed, notional labour demand and output supply decrease by 1.7% and 4% per quarter respectively as a result of the efficiency loss on existing plants. These effects seem rather strong, possibly compensating for the probable overestimation of c_1 and b_1.

6.4 Labour Supply

The elasticity of intertemporal substitution, d_4, and the elasticity with respect to the permanent net real wage, d_3, are estimated at 0.201 and 0.177 respectively. The value obtained for d_5 says that changes in the actual net real wage get translated into the permanent one to an extent of 50% within 5 quarters. These estimates look reasonable. Parameter d_2 indicates a substantial negative time trend in labour supply relative to the potential labour force of nearly 0.4% per quarter (real wages held constant). Considering the rising participation in higher education, the decline in the average retirement age and the fact that foreign women with formerly high participation rates have been steadily adapting to Swiss women's behaviour, this result is not implausible though. Note however that the individual labour supply parameters are not well determined econometrically[16].

7 Simulations

7.1 Fit of the model

A first impression of the model's fit is provided by the standard errors of the individual structural equations[17]. To check the fit of the complete model, we insert actual values for all predetermined variables, set the error terms to zero and compute the theoretical values of the observable endogenous variables (static simulation)[18]. The associated R^2's are:

Variable	Y	L	P_G	P_L	I
R^2	0.973	0.968	0.951	0.883	0.915

The fit turns out to be acceptable. Note however that any model with lagged endogenous variables can be expected to track well in a static simulation if the data are strongly autocorrelated, which is the case here.

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(16) Compare the sensitivity analysis in Stalder (1989a), where an identical labour supply equation is estimated in the framework of a model confined to the labour market.

(17) See summary table. The SER referring to residual $\hat{u}_1$ in (18.1) translates into a standard error of 0.0134 relative to the sample mean of Y^d. The SER of investment $(\widehat{u}_3)$ amounts to 0.036 relative to the sample mean of I. The other SERs in the table are already stated in relative terms.

(18) Due to the nonlinearity of the model, this procedure does not yield exact conditional expectations of the endogenous variables.

7.2 Disequilibria and spillovers

The static simulation also generates values for the *latent demands and supplies*. These provide some interesting insights into the development of the Swiss economy (see fig. 1, in the appendix) .

Goods demand Y^d fluctuates with a short lead around more inert actual output Y, entailing changes in buffer stocks BU (unfilled orders minus inventories). Buffer stocks feed back onto firms' planned output supply Y^{sp}. For instance, when Y^d falls short of Y (1971, 1974-75, 1980-82), BU decreases and pushes Y^{sp} below profitable capacities $\tilde{Y}^s$ (notional supply), leading to a *Keynesian spillover* onto effective labour demand L^d. In boom periods (1969-70, 1973, 1980), effective output Y is smaller than Y^{sp}, reflecting that firms were partly constrained by labour supply in these periods. This *Repressed Inflation spillover* amounts to a maximum output reduction of 3% in 1969-70. It is numerically less important than the Keynesian spillover, which causes a 13% reduction in labour demand in the 1975 recession.

On the *labour market*, the model implies varying amounts of excess demand in the late 60s and early 70s, up to 5.5% in 1969-70. After the drastic drop in labour demand in the mid-70s, employment becomes mainly demand-determined, excess supply reaching peak values of 6% in 1975 and 1982-83. At the end of the simulation period, the labour market moves into an aggregate equilibrium; due to the structural mismatch at the micro level, employment L lies however slightly more than 2% below the intersection of L^d and L^s ($SURE$).

The fluctuations in labour demand arise mainly from Keynesian spillover effects. Profitable capacities and notional labour demand show less cyclical variability. The Keynesian spillover is strongest in the recessions of 1975 and 1982-83. Note however the flattening trend in profitable capacities and the decline in notional labour demand from 1972 to 1980. In the first three years of this period, these developments can be traced back to a *profitability squeeze* due to fast growing wages, a sudden monetary restriction and a sharp revaluation of the Swiss Franc. It would thus be rather misleading to describe the 1975 recession in purely 'Keynesian' terms. After 1975, when profitability was recovering, the ongoing reduction in notional labour demand reflects the downward adjustment of capacities to the lower level of economic activity, captured by the excess demand term of the investment equation.

Unemployment rates generated by the model reach cyclical peaks of about 6% (fig. 2). This result and the estimate of $SURE$ (2.28% in 1985) strongly contrast with *official unemployment rates* that hardly ever exceeded 1%. The discrepancy can explained as follows:

1. Swiss unemployment statistics are based on the number of persons *registered* at the *employment offices*. Registration is a requirement for collecting unemployment benefits. Until 1977 coverage by unemployment insurance was however extremely low in Switzerland so that the incentive to register was probably weak. In 1977, unemployment insurance became mandatory for all employees. From that time on, one may assume that a majority of active job seekers got registered.

2. Unemployment statistics count the number of *full-time* unemployed. The employment variable L in our model however measures *total hours worked*. Therefore, the use of short-time work during recessions, which is extensive in Switzerland, shows up in the model but is not reflected in official unemployment figures. In the trough of 1982, for example, short-time work amounted to one half of full-time unemployment in terms of working hours[19].

3. The estimate of unemployment produced by our model is based on a specification of labour supply that does *not* include a *discouraged worker effect*. Hence it reflects the amount of labour households would like to supply if jobs were available at the going wage. However, people involuntarily unemployed in this sense may temporarily withdraw from the labour force when they regard the chances of finding a job as low. Such "flexible' behaviour seems to be widespread in Switzerland, especially among married women and people in the retirement age, keeping official unemployment low[20].

Nevertheless, even on basis of our estimates, the Swiss labour market situation looks quite idyllic. In particular, the structural mismatch seems to be lower than in most other countries for which similar models have been estimated[21]. Moreover, unemployment after both recessions quickly returned to low levels. One should stress, however, that this is not to be attributed to a more favourable course of labour demand but rather to the remarkable downward flexibility in labour supply brought about by the high turnover among foreign workers. But the share of foreigners with only temporary work permits has

(19) See OECD (1985).

(20) Every ten years a census is taken in Switzerland. In the 1980 census (December) 24' 500 persons declared themselves as unemployed, corresponding to an unemployment rate of 0.9%. This figure is pretty close the estimate implied by our model (1.1% in 1980Q4), whereas official unemployment was as low as 0.2% in this period.

(21) See the country studies reported in Drèze et al. (1990).

been steadily falling since the mid-1970s. This tendency has already limited the possibility of using foreign labour as a cyclical buffer in the recession of 1982-83 — and will further reduce it in future.

7.3 Dynamic tracking performance and stability

Next, we want to see how well the model tracks in a dynamic simulation. This provides a numerical test for dynamic stability that seems indispensable in view of the non-linearities and stock-flow dynamics included in the model. Of course, due to the buffer mechanism (18.1) and the accumulation of vintages in (25), it is an intrinsic property of the model that errors are carried over to a significant degree from period to period. Therefore, we should not be troubled by dynamic tracks that diverge for some prolonged periods from actual values. Explosive deviations would however indicate dynamic instability.

As shown in fig. 3, the movements in buffer stocks are reproduced reasonably well and there are no progressive departures from actual values. This also holds for the other endogenous variables of the model. In case of investment, however, deviations are rather large. In particular, simulated investment keeps on expanding throughout the 1982 recession and the following years. As the supply effect of investment via capacities on actual output exceeds its contribution to aggregate demand, there is a counterfactual decline in buffer stocks during the last two years of the simulation period. In general, however, actual developments are tracked fairly well by the model[(22)].

Another check of dynamic stability can be performed by exposing the model to a *demand shock*[(23)]. To carry out the simulation in a meaningful way, we must consider a characteristic feature of the model: the response of output and employment to an exogenous shock depends on the prevailing rationing situation, being strongest if both P_G and P_L are low (Keynesian unemployment). Therefore, if we were to use actual developments in the economy as reference course, the associated changes in the rationing situation would interfere with the dynamic adjustments arising from the demand shock. To prevent such

[(22)] The dynamic tracks become much better in the last couple of years if investment is treated as exogenous.

[(23)] Doing so, we have to keep in mind that variables that can be considered 'weakly exogenous' for estimation have to meet the requirement of 'strong exogeneity' in a dynamic simulation (Engle, Hendry and Richard, 1983). As strong exogeneity seems highly questionable for several of the model's exogenous variables, in particular prices and wages, the simulation can neither prove the effectiveness nor the desirability of a demand stimulation. It may shed some light on the dynamics of the model though.

a confusion, we first set the model on a hypothetical growth path on which P_G and P_L remain constant at their sample means of 0.49 and 0.33 respectively.

To simulate a demand shock, we raise parameter a_0 in (24) for one period by 500, amounting to a 1.75% impulse to Y_d. As shown in fig. 4, the peak effect on output is only 0.75% but, due to the multiplier-accelerator process, positive deviations persist for many periods. Initially, the output response falls short of the increase in goods demand because of production smoothing behaviour. But output quickly catches up and exceeds then demand. The response of profitable capacities shows notably more inertia, reaching a peak deviation of 0.6% after three years. In the long run, all variables return with dampened oscillations to their reference paths. The oscillatory behaviour of the model originates from the investment equation, which implies some "overshooting" of capacities. The cycle length of almost 10 years is not entirely convincing.

8 Summary and conclusions

This study analyses the development of the Swiss economy on basis of a macro disequilibrium model. The aggregate markets for goods and labour are viewed as a continuum of *micro markets* with differing demand/supply ratios. By aggregation, the "sharp-cornered" micro-level minimum conditions are converted into continuous macro relationships, mapping aggregate demands and supplies onto observed transactions and regime proportions (measured by survey data).

Firms decisions on output, labour demand and investment are specified on basis of a *vintage-approach*. The model further allows for production smoothing buffer stocks. As compared to the usual set-up of disequilibrium models, this gives rise to a modification of the short-run link between goods demand and output but does not call in question the spillover concept fundamentally.

The model developed along these lines combines traditional Keynesian demand-side analysis with supply-side considerations (profitability, relative prices). The aggregate structure is inherently nonlinear, reflecting that the weight of demand-side and supply-side factors varies systematically through the cycle depending on the aggregate mix of regimes. Estimation of the model with quarterly data leads to the following *conclusions*:

- In the late 60s and early 70s, the *aggregate labour market* is characterized by varying amounts of excess demand. After the

1975 recession, the model in general implies situations of excess supply. At the end of the estimation period (1985Q4), the labour market moves into an aggregate equilibrium. The micro-level mismatch increases over time.

- The fluctuations in labour demand are mainly caused by *Keynesian spillovers*. Notional labour demand and *capacity output* show less cyclical variability.

- In boom periods, effective output falls short of planned supply since firms are unable to fully realize labour demand. This *Repressed inflation* spillover is relatively small compared to the Keynesian spillover.

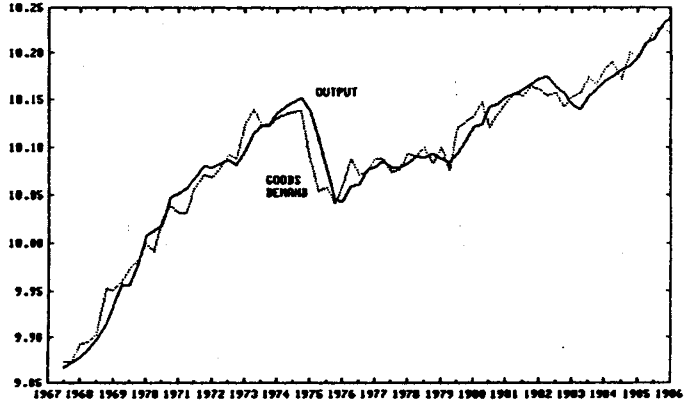
- Driving force behind the changes in goods demand are cyclical movements in the world economy. These fluctuations set in motion an internal *multiplier-accelerator* mechanism that itself exhibits cyclical properties.

By modelling the demand-side of the economy along with the supply-side and by allowing for structural imbalances at the micro level, the approach of this paper provides —at least potentially— a rich basis for policy analysis. In this respect, however, a disturbing flaw of the model is the exogeneity of prices and wages. To assess the persistence of the different rationing situations and to discuss policy measures, one would have to analyse how prices and wages respond to disequilibria. Endogenizing the process of price and wage formation should therefore be a prior topic of future research[24].

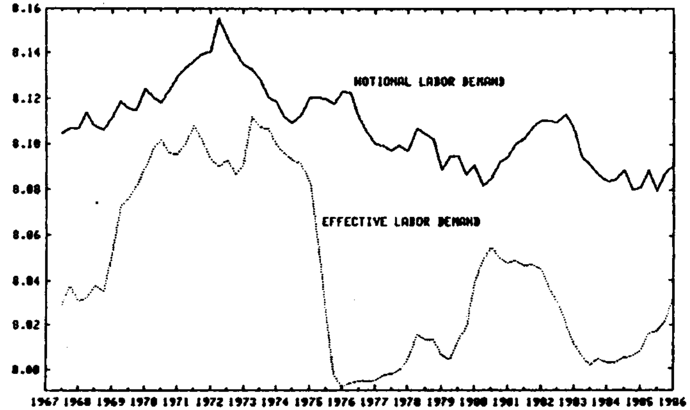
[24] Some models for other countries have already accomplished this task; see in particular the work reported in Drèze et al. (1990).

Figure 1

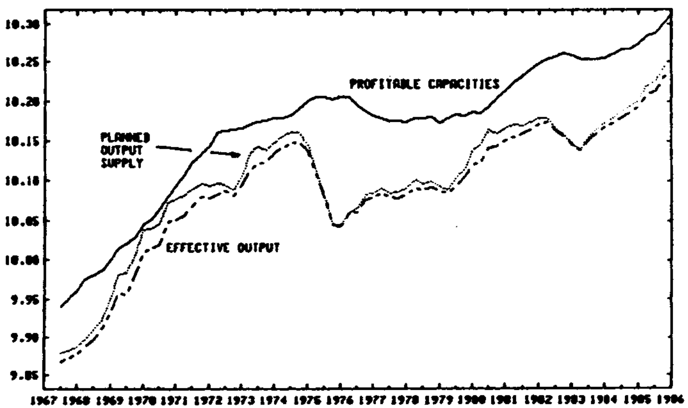
Latent Demands and Supplies (derived from static simulation, log. nat)



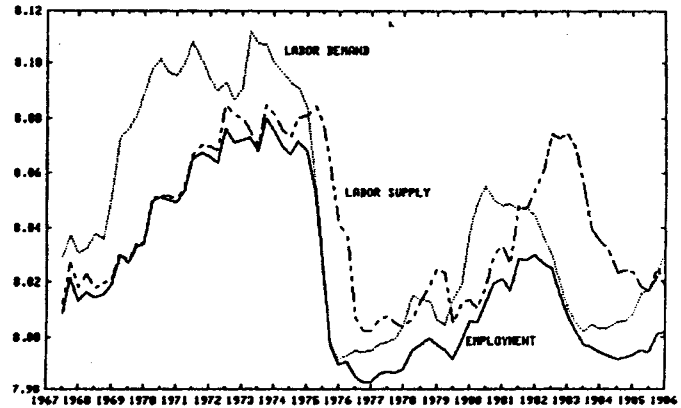
Goods Demand Y^d and Output Y



Notional and Effective Labor Demand, $\widetilde{L}^d$ and L^d



Profitable Capacities $\widetilde{Y}^s$, Planned Output Supply Y^{sp} and Effective Output Y



Labor Demand L^d, Labor Supply L^s and Employment L

Figure 2: Unemployment Rate (derived from static simulation

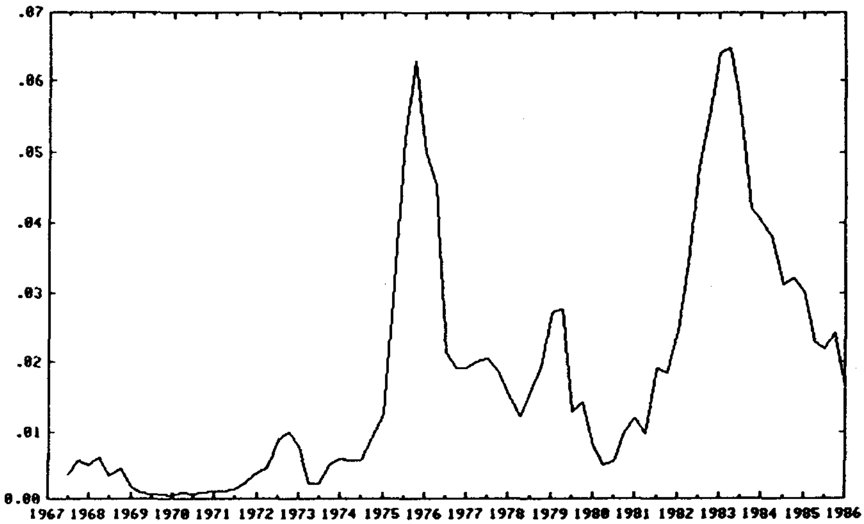
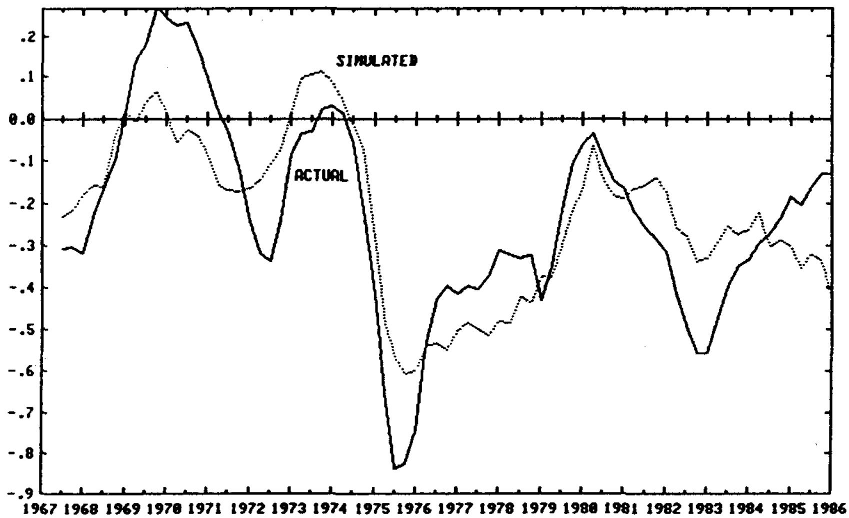
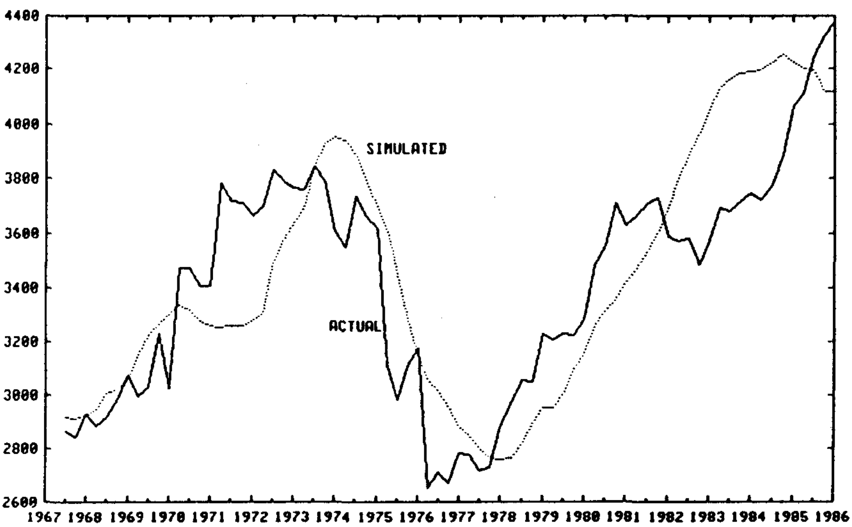


Figure 3: Dynamic Traking Performance



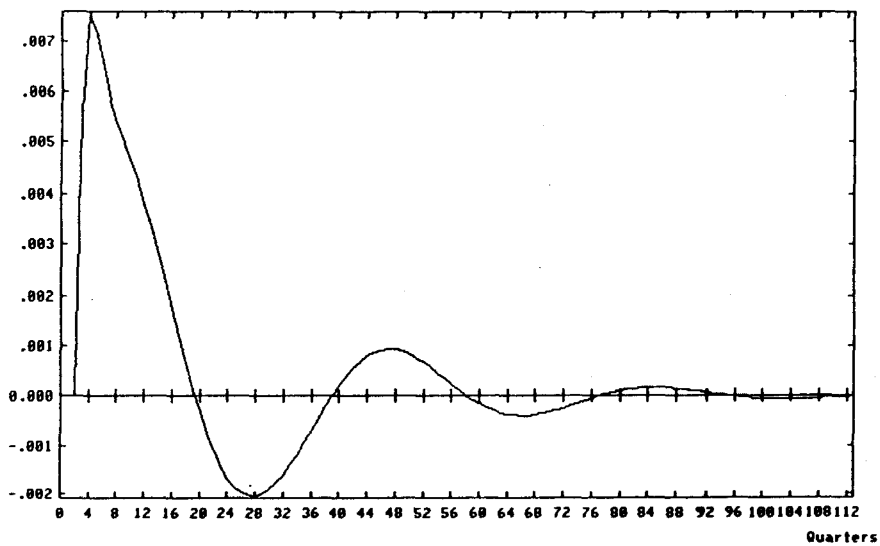
Buffer stocks BU/k



Investement I

Figure 4

Dynamic Simulation of a One-time Demand Schock (1.75% of GDP – Effect on Output $\ln(Y)$



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